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Please find below and/or attached an Office communication concerning this application or proceeding.

PTO-90C (Rev. 10/03)

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE <u>3</u> MONTH(S) FROM
THE MAILING DATE OF THIS COMMUNICATION.
- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☐ Responsive to communication(s) filed on _____.

2a)☐ This action is **FINAL**.   2b)☒ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☐ Claim(s) _____ is/are pending in the application.

    4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *1-46* is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☒ The specification is objected to by the Examiner.

10)☒ The drawing(s) filed on *19 July 2004* is/are: a)☐ accepted or b)☒ objected to by the Examiner.

    Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

    Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

    a)☐ All   b)☐ Some * c)☐ None of:

    1.☐ Certified copies of the priority documents have been received.

    2.☐ Certified copies of the priority documents have been received in Application No. _____.

    3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

    * See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)

2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)

3) ☒ Information Disclosure Statement(s) (PTO-1449 or PTO/SB/08)
    Paper No(s)/Mail Date _____.

4) ☐ Interview Summary (PTO-413)
    Paper No(s)/Mail Date. _____ .

5) ☐ Notice of Informal Patent Application (PTO-152)

6) ☐ Other: _____.

DETAILED ACTION

Drawings

1.   Figures 1B and 4 should be designated by a legend such as --Prior Art-- because only that

which is old is illustrated. See MPEP § 608.02(g). Corrected drawings in compliance with 37

CFR 1.121(d) are required in reply to the Office action to avoid abandonment of the application.

The replacement sheet(s) should be labeled "Replacement Sheet" in the page header (as per 37

CFR 1.84(c)) so as not to obstruct any portion of the drawing figures. If the changes are not

accepted by the examiner, the applicant will be notified and informed of any required corrective

action in the next Office action. The objection to the drawings will not be held in abeyance.

2.   The drawings are objected to as failing to comply with 37 CFR 1.84(p)(5) because they

include the following reference character(s) not mentioned in the description: 118 (Fig 2A), 142-

1 (Fig 6), 156-2 (Fig. 7), 156-3 (Fig. 7), and 283 (in paragraph 67 of the specification, 282 in Fig.

13A is described as a bundle of rays.) Corrected drawing sheets in compliance with 37 CFR

1.121(d), or amendment to the specification to add the reference character(s) in the description in

compliance with 37 CFR 1.121(b) are required in reply to the Office action to avoid

abandonment of the application. Any amended replacement drawing sheet should include all of

the figures appearing on the immediate prior version of the sheet, even if only one figure is being

amended. Each drawing sheet submitted after the filing date of an application must be labeled in

the top margin as either "Replacement Sheet" or "New Sheet" pursuant to 37 CFR 1.121(d). If

the changes are not accepted by the examiner, the applicant will be notified and informed of any

required corrective action in the next Office action. The objection to the drawings will not be

held in abeyance.

Specification

3.   The specification is objected to as failing to provide proper antecedent basis for the

claimed subject matter. See 37 CFR 1.75(d)(1) and MPEP § 608.01(o). Correction of the

following is required: Claims 2, 3, 4, 13, 14, and 15 recite "view plane of the light source"

without proper antecedent terminology in the descriptive portion of the specification.

Claim Rejections - 35 USC § 103

4.   The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all

obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in
> section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are
> such that the subject matter as a whole would have been obvious at the time the invention was made to a person
> having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the
> manner in which the invention was made.

5.   The factual inquiries set forth in *Graham* v. *John Deere Co.*, 383 U.S. 1, 148 USPQ 459

(1966), that are applied for establishing a background for determining obviousness under 35

U.S.C. 103(a) are summarized as follows:

1.   Determining the scope and contents of the prior art.
2.   Ascertaining the differences between the prior art and the claims at issue.
3.   Resolving the level of ordinary skill in the pertinent art.
4.   Considering objective evidence present in the application indicating obviousness
        or nonobviousness.

6.   This application currently names joint inventors. In considering patentability of the

claims under 35 U.S.C. 103(a), the examiner presumes that the subject matter of the various

claims was commonly owned at the time any inventions covered therein were made absent any

evidence to the contrary. Applicant is advised of the obligation under 37 CFR 1.56 to point out

the inventor and invention dates of each claim that was not commonly owned at the time a later

invention was made in order for the examiner to consider the applicability of 35 U.S.C. 103(c)

and potential 35 U.S.C. 102(e), (f) or (g) prior art under 35 U.S.C. 103(a).

7.   Claims 1-15, 17-24, 26, 28-31, 33, 34, and 36-38 are rejected under 35 U.S.C. 103(a)

as being unpatentable over Peter-Pike Sloan, Jan Kautz, John Snyder, "Precomputed

radiance transfer for real-time rendering in dynamic, low-frequency lighting

environments," July 2002, ACM Transactions on Graphics (TOG), v. 21 n. 3 (herein

referred to as "Sloan et al") in view of Timothy J. Purcell, Ian Buck, William R. Mark, Pat

Hanrahan, "Ray tracing on programmable graphics hardware," July 2002, In Proceedings

of the 29th Annual Conference on Computer Graphics and Interactive Techniques (herein

referred to as "Purcell et al.")

8.   With regard to claim 1, Sloan et al teaches "a method for presenting lighting

characteristics associated with a display object in real-time, comprising: a ray tracing algorithm

executing that includes generating a ray associated with a point on the display object" (5th

paragraph of section 5: "In the first pass, for each p ∈ O, we cast shadow rays in the

hemisphere about p's normal Np, using the hierarchy to cull directions outside the

hemisphere. "). Sloan et al teaches "determining an approximation of a transfer function

component using at least one basis function" in the equations given in the 6th and 7th paragraphs

of section 5. Sloan et al does not use this explicit language; however one of ordinary skill in the

art would recognize this feature from the description of the terms of the equation in the 2nd

paragraph of section 5 and the 3rd paragraph of section 4:

A transfer matrix $(M_p)_{ij}$ is useful for glossy surfaces and represents a linear

transformation on the lighting vector which produces projection coefficients for an entire

> *spherical function of transferred radiance L'$_p$(s) rather than a scalar...Components of*
>
> *(M_p)$_{ij}$ represent the linear influence of the j-th lighting coefficient of incident radiance*
>
> *(L_p)$_j$ to the i-th coefficient of transferred radiance(L'$_p$)$_i$.*

Sloan et al does not teach ray tracing on stream processor. Purcell et al teaches "executing a ray

tracing algorithm through a stream processor" (*Figure 2, page 705*).

9.   With regard to claim 6, Sloan et al teaches "a method for determining secondary

illumination features for an object to be displayed, comprising: calculating an approximation to a

transfer function associated with at least one basis function" in the equations given in the 6th and

7th paragraphs of section 5 (as shown with regard to claim 1); "wherein the approximation to the

transfer function represents a component of the secondary illumination features" (*4th paragraph*

of section 5: "...L'$_p$(s) includes shadowing/scattering effects due to the presence of [object] O

while L$_p$(s) represents incident lighting assuming O was removed from the scene. Components of

(M_p)$_{ij}$ represent the linear influence of the j-th lighting coefficient of incident radiance (L_p)$_j$ to the

i-th coefficient of transferred radiance(L'$_p$)$_i$. "). In 5th paragraph of section 5, Sloan et al

teaches generating rays from a point on the object (*"In the first pass, for each p ∈ O, we cast*

shadow rays in the hemisphere about p's normal Np... "), and "determining if a ray intersects a

surface" ("*We tag each direction s$_d$ with an occlusion bit, 1 − V$_p$(s$_d$), indicating whether s$_d$ is in*

the hemisphere and intersects O again (i.e., is self-shadowed by O). "); however, Sloan et al does

not teach ray tracing on a stream processor. Purcell et al teaches "providing a stream processor

capable of identifying a path associated with a ray" (*page 705, 1st paragraph of section 2.3: "In*

order to guide the mapping of new applications to graphics architectures, we propose that we

view next generation graphics hardware as a streaming processor. "; 4th paragraph of section 3,

titled "Streaming Ray Tracing": "The traversal kernel steps rays through the grid until the ray

encounters a voxel containing triangles "); "generating a ray from a point on the object" (*1st*

paragraph of section 3.1.2: "The traversal stage searches for voxels containing triangles ... The

second part steps along the ray enumerating those voxels pierced by the ray. "); "determining if

the path of the ray intersects a surface" (*4th paragraph of section 3, titled "Streaming Ray*

Tracing": "The intersection kernel is responsible for testing ray intersections with all the

triangles contained in the voxel. ").

10.   With regard to claim 23, Sloan et al teaches "a method for calculating an approximation

to a transfer function defined by at least one basis function for rendering shading characteristics

of an object in real time, comprising: identifying a point on the object; calculating a lighting

function for the point" (*1st paragraph of section 5: "As a preprocess, we perform a global*

illumination simulation over an object O using the SH basis over the infinite sphere as

emitters. "; *6th paragraph of section 5: "For diffuse surfaces, at each point $p \in O$ we further*

compute the transfer vector by SH-projecting M_p [transfer function] from [equation] (10). ").

Sloan et al teaches "determining a direct illumination transfer function for the point" by means of

a ray tracer (*1st paragraph of section 5: "As a preprocess, we perform a global illumination*

simulation over an object O using the SH basis over the infinite sphere as emitters. "; *3rd*

paragraph of section 5: "An initial pass simulates direct shadows from paths leaving L and

reaching sample point $p \in O$. "). Sloan et al does not teach ray tracing on a stream processor in

real-time. Purcell et al teaches "applying a ray tracing algorithm through a stream processor"

(*Figure 2, page 705*). Purcell et al teaches "determining a secondary lighting contribution in real

time through a series of multiply and add operations applied to data resulting from the ray tracing

algorithm" (*4th paragraph of section 3: "Additionally, the shading kernel may generate shadow or secondary rays; in this case, these new rays are passed back to the traversal stage."*). With regard to the multiply and add operations for secondary lighting for secondary illumination, the triangle intersection stage (as shown in Figure 2 on page 705 of Purcell et al) occurs after the traversal stage. Figure 5 (Code for ray-triangle intersection) shows the dot product operation for two vectors on lines 12, 14, and 15. Furthermore, Purcell et al refers to the method as "real-time ray tracing" in the first sentence of the 2nd paragraph of section 1.

11.   With regard to claim 28, Sloan et al teaches "calculating a lighting function for an object to be rendered using a basis function, comprising: calculating a transfer function approximation of the lighting function" (*3rd paragraph of section 4: "A transfer matrix $(M_p)_{ij}$ is useful for glossy surfaces and represents a linear transformation on the lighting vector which produces projection coefficients for an entire spherical function of transferred radiance $L'_p(s)$ rather than a scale."*). Furthermore, Sloan et al states in the 4th paragraph of section 1:

> *The object's shaded "response" to its environment can be viewed as a transfer function, mapping incoming to outgoing radiance, which in this case simply performs a cosine-weighted integral.*

Sloan et al does not teach using a stream processor to compute the rays, which computes the transfer function (*1st paragraph of section 5: "As a preprocess, we perform a global illumination simulation over an object O using the SH basis over the infinite sphere as emitters."*). Purcell et al teaches a ray tracer using a stream processor as shown in the paragraphs above.

12.   In reference to computing the transfer function using ray tracing as recited in claims 1, 6,

23 and 28, Sloan et al states that the "light gathering solution technique is a straightforward

adaptation of existing approaches [7][25] and could be accelerated in many ways," noting that

[7] is a ray-tracing algorithm. At the time of the invention, it would have been obvious to a

person of ordinary skill in the art to accelerate the computation of radiance transfer as taught by

Sloan et al, by using a stream processor to trace rays as taught by Purcell et al. The motivation

for doing so would have been to achieve better performance tracing rays as stated by Purcell et al

in section 2.3, which would be advantageous for interactive systems. Therefore, it would have

been obvious to combine Sloan et al with Purcell et al to obtain the invention as specified in

claims 1, 6, 23 and 28.

13.   Claim 2 is met by the combination of Sloan et al and Purcell et al, wherein Sloan et al

teaches "determining whether the ray is within a view plane of a light source" (*5th paragraph of*

section 5: "In the first pass, for each p $\in$ O, we cast shadow rays in the hemisphere about p's

normal Np...We tag each direction s_d with an occlusion bit, 1 – $V_p(s_d)$, indicating whether s_d is in

the hemisphere and intersects O again (i.e., is self-shadowed by O). "). Sloan et al does not use

this explicit language in the 5th paragraph of section 5; however, one of ordinary skill in the art

would recognize that a ray occluded by an object is not in the view plane of the light.

14.   Claim 3 is met by the combination of Sloan et al and Purcell et al, wherein Sloan et al

teaches "if the ray is within the view plane of the light source, then the method includes,

determining a direct illumination component of the lighting characteristic" (*5th paragraph of*

section 5: "completely unoccluded bins/samples receive only direct light from the

environment. ").

15.   Claim 4 is met by the combination of Sloan et al and Purcell et al, wherein Sloan et al

teaches "if the ray is not within the view plane of the light source, then the method includes,

determining a self interreflection component of the lighting characteristic" (*5th paragraph of*

section 5: "Self-occluded directions and bins are tagged so that we can perform further

interreflection passes on them").

16.   Claim 5 is met by the combination of Sloan et al and Purcell et al, wherein Sloan et al

teaches "repeating the determining of an approximation of a transfer function component for a

series of basis functions"(*2nd paragraph of section 4: "In other words, each component of $(M_p)_i$*

represents the linear influence that a lighting basis function $(L_p)_i$ has on shading at p."); and

rendering the display object using the approximation of the transfer function component for the

series of basis functions" (*1st paragraph of section 6: "Rendering [model] O requires the*

following steps at run-time:...compute incident lighting $\{L_{Pi}\}$ at one or more sample points P_i

near O in terms of the SH basis.").

17.   Claim 7 is met by the combination of Sloan et al and Purcell et al, wherein Purcell et al

teaches a "stream processor capable of identifying a path associated with a ray includes, reading

data associated with the ray" (*4th paragraph of section 3: "The traversal kernel reads the stream*

of rays produced by the eye ray generator."; 1st paragraph of section 3.1.2: "The second part

steps along the ray enumerating those voxels pierced by the ray"); and "reading polygon data

associated with the path" (*4th paragraph of section 3: "The traversal kernel steps rays through*

the grid until the ray encounters a voxel containing triangles. The ray and voxel address are

output and passed to the intersection kernel."; Figure 4).

18.   Claim 8 is met by the combination of Sloan et al and Purcell et al, wherein Purcell et al

teaches an "operation of generating a ray from a point on the object includes, determining a

voxel traversed by a ray segment" (*1st paragraph of section 3.1.2: "The traversal stage searches

for voxels containing triangles...The second part steps along the ray enumerating those voxels

pierced by the ray.")*.

19.   Claim 9 is met by the combination of Sloan et al and Purcell et al, wherein Purcell et al

teaches "if the path of the ray does not intersect the surface, then the method includes,

determining a next voxel traversed by a next ray segment" (*3rd paragraph of section 3: "If no hit

occurs, the ray is passed back to the traversal kernel and the search for voxels containing

triangles continues.")*.

20.   Claim 10 is met by the combination of Sloan et al and Purcell et al, wherein Purcell et al

teaches "if the ray intersects a surface, then the method includes, recording data associated with

the location of the surface intersection" (*4th paragraph of section 3: "If ray-triangle intersection

(hit) occurs in that voxel, the ray and the triangle that is hit is output for shading.")*; and

"generating a next ray" (*3rd paragraph of section 3.1.4: "The shading kernel optionally

generates shadow, reflection, refraction, or randomly generated rays.")*; and "if the ray does not

intersect a surface, then the method includes, reading data associated with a next voxel" (*3rd

paragraph of section 3: "If no hit occurs, the ray is passed back to the traversal kernel and the

search for voxels containing triangles continues."; 2nd paragraph of section 3.1.2: "After each

step, the kernel queries the grid data structure which is stored as a 3D texture.")*; "advancing the

ray through the next voxel" (*1st paragraph of section 3.1.2: "The traversal stage searches for

voxels containing triangles...The second part steps along the ray enumerating those voxels*

pierced by the ray. "); "and repeating if the path of the ray intersects the surface" (*1st paragraph*

of section 3.1.2: "The traversal stage searches for voxels containing triangles...The second part

steps along the ray enumerating those voxels pierced by the ray. ").

21.   Claim 11 is met by the combination of Sloan et al and Purcell et al, wherein Purcell et al

teaches, "determining if the surface intersection is a closest surface intersection" (*Figure 3 (c))*.

22.   Claims 12-15 and 17-22 are rejected with the rationale of claims 1-4 and 6-11

respectively. Claims 12-15 and 17-22 are claims 1-4 and 6-11 recited as a computer readable

medium with having program instructions.

23.   Claim 24 is met by the combination of Sloan et al and Purcell et al, wherein Purcell et al

teaches "the multiply and add operations are performed by the stream processor" (*Figure 5:*

code for ray tracing triangles.). Purcell et al does not use the explicit language "multiply and

add operations", but one of ordinary skill in the art would recognize that this feature is inherent

from lines 12, 14, and 15 in the code presented in Figure 5, where the dot product of two vectors

is computed.

24.   Claim 26 is met by the combination of Sloan et al and Purcell et al, wherein Sloan et al

teaches "repeating the identifying and the calculating for multiple points on the object" (*2nd*

paragraph of section 5: "An initial pass simulates direct shadows from paths leaving L and

reaching sample points p ∈ O...In each pass, energy is gathered to every sample point p. ").

25.   Claim 29 is met by the combination of Sloan et al and Purcell et al, wherein Sloan et al

teaches a "transfer function approximation is associated with the basis function that characterizes

a global illumination associated with the object" (*2nd paragraph of section 4: "A transfer vector*

$(M_p)_i$ is useful for diffuse surfaces and represents a linear transformation on the lighting vector

producing scalar exit radiance...each component of (Mp)i represents the linear influence that a

lighting basis function $(L_p)_i$ has on shading at p. ").

26.   Claim 30 is met by the combination of Sloan et al and Purcell et al, wherein Sloan et al

teaches a "transfer function approximation is a set of coefficients configured to describe a

surface reflectance" (*4th paragraph of section 4: "Components of $(M_p)_{ij}$ represent the linear*

influence of the j-th lighting coefficient of incident radiance $(L_p)_j$ to the i-th coefficient of

transferred radiance(L'_p)).

27.   Claim 31 is met by the combination of Sloan et al and Purcell et al, wherein Sloan et al

teaches rendering an object (*1st paragraph of section 6: "We now have a model O capturing*

radiance transfer at many points p over its surface, represented as vectors or matrices.

Rendering O requires the following steps at run-time:...").

28.   Claims 33, 34, and 36-38 are rejected with the rationale of claims 23, 26, and 28-30

respectively. Claims 33, 34, and 36-38 are claims 23, 26, and 28-30 recited as a computer

readable medium with having program instructions.

29.   Claims 16 and 25 are rejected under 35 U.S.C. 103(a) as being unpatentable over

Sloan et al in view of Purcell et al and in further view of Robert L. Cook, "Stochastic

sampling in computer graphics," Jan. 1986, ACM Transactions on Graphics (TOG), v.5

n.1, p.51-72 (herein referred to as "Cook.")

30.   As previously stated, the Sloan et al and Purcell et al combination meets the limitations of

claim 12. With regard to claim 16, the Sloan et al and Purcell et al combination is silent as to

biased or unbiased approximators. Cook et al teaches "applying one of a biased" approximator

(*1st paragraph of section 5.2: "Sometimes we need to weight the samples...A better approach is*

importance sampling, in which the sample points are distributed so that the chance of a location being sampled is proportional to the value of the filter at that location. "; 3rd paragraph of section 5.2: "For example, for the reflection ray, we create a lookup table based on the specular reflection function.") and "unbiased approximator" (*1st paragraph of section 5.1: "One way to distribute the rays in the additional dimensions is with uncorrelated random values.")*.

31.   As previously stated, the Sloan et al and Purcell et al combination meets the limitations of claim 23. With regard to claim 25, the Sloan et al and Purcell et al combination is silent as to biased or unbiased approximators. Cook et al teaches "applying one of a biased approximator" in the 1st paragraph of section 5.2 as shown in the paragraph above.

32.   Cook et al, Sloan et al and Purcell et al are analogous art because they are from the same problem solving area: computing illumination on graphics hardware. At the time of the invention it would have been obvious to a person of ordinary skill in the art to apply one of an unbiased approximator and the biased approximator as taught by Cook et al in the ray tracer taught by the Purcell et al and Sloan et al combination. The motivation for doing so would be to provide a pattern to distribute the rays, or in some cases, such as determining direct lighting, to use a biased approximator to direct where the rays will go to avoid unproductive computations *(Cook et al in the 1st paragraph of section 5.2 states that importance sampling "puts the samples where they will do the most good.")*. Therefore, it would have been obvious to combine Sloan et al and Purcell et al with Cook to obtain the invention as specified in claims 16 and 25.

33.   Claims 27 and 35 are rejected under 35 U.S.C. 103(a) as being unpatentable over Sloan et al in view of Purcell et al and in further view of U.S. Patent No. 6,268,860 to Bonello (herein referred to as "Bonello.")

34.   As previously stated, the Sloan et al and Purcell et al combination meets the

limitations of claim 31. With regard to claim 27, Sloan et al does not disclose delayed evaluation

based on frames. Bonello discloses performing a calculation "for a portion of the multiple points

during a first frame of image data, and performing the calculation for a remainder of the multiple

points during a next frame of image data" (*lines 41-47 of column 8: " In this variation, the*

invention makes use of the knowledge that the illumination situation rarely changes between

images (frames) that are adjacent in time, so it suffices to calculate precisely the relevance of the

individual light sources for only every third frame, for example, and retain it in the display of the

frames located between them in time. ").

35.   Sloan et al, Purcell et al and Bonello are analogous art because they the same problem

solving area: improving the efficiency of illumination calculations for image generation. At the

time of the invention it would have been obvious to a person of ordinary skill in the art to defer

running illumination calculation on a portion of the data as taught by Bonello in the image

generation system as taught by the Sloan et al and Purcell et al combination. The motivation for

doing so would have been to reduce the amount of computation for displaying computer models

for each frame as stated by Bonello in lines 31-32 of column 8, which would improve the

performance of an interactive system.

36.   Claim 35 is rejected with the rationale of claim 27. Claim 35 is claim 27 recited as a

computer readable medium.

37.   **Claim 32 is rejected under 35 U.S.C. 103(a) as being unpatentable over Sloan et al in**

view of Purcell et al and in further view of Tomas Möller, Eric Haines, "Real-Time

Rendering," 1999, A.K. Peters, p. 68 (herein referred to as "Möller et al.")

38.   As previously stated, the Sloan et al and Purcell et al combination meets the limitations of

claim 31. With regard to claim 32, Sloan et al does not disclose linear interpolation. Möller et al

teaches, "linearly interpolating a color of the object across a polygon" (*2nd paragraph of p. 68:*

"In Gouraud shading [138], the lighting at each vertex of a triangle is determined, and these

lighting samples (i.e., computed colors) are interpolated over the surface of the triangle. ").

39.   Sloan et al, Purcell et al and Möller et al are analogous art because they are from the

same problem solving area: real-time rendering. Möller et al states in the 3rd paragraph on page

68, "Most graphics hardware implement Gouraud shading because of its speed and much

improved quality." At the time of the invention it would have been obvious to a person of

ordinary skill in the art to incorporate interpolation as taught by Möller et al in the color

computations of the combination of Sloan et al and Purcell et al. The motivation for doing so

would have been to give a "smooth look to curved surfaces" (3rd paragraph of page 68, Möller et

al) without having to compute the color attribute at each point on the surface of the object.

40.   Claims 39-46 are rejected under 35 U.S.C. 103(a) as being unpatentable over U.S.

Patent No. 6,639,595 to Drebin et al (herein referred to as "Drebin et al") in view of Sloan

et al and in further view of Purcell et al.

41.   With regard to claim 39, Drebin et al discloses "A computing device, comprising: a

graphics processing unit (GPU) capable of determining lighting characteristics for an object in

real time" (*lines 58-60 of column 4: "In this example, system 50 is capable of processing,*

interactively in real time, a digital representation or model of a three-dimensional world."; lines

9-13 of column 9: "As discussed above, transform unit 300 in the example embodiment performs

lighting in addition to geometric transformations, clipping, culling and other functions. In the

example embodiment, transform unit 300 supports lighting in hardware as a per-vertex

calculation. "). Drebin et al does not disclose a basis function or a stream processor. Sloan et al

discloses "the lighting characteristics defined through a basis function" (*1ˢᵗ paragraph of section*

4: "...we first parameterize incident lighting at points p ∈ O, denoted Lₚ(s), using the [Spherical

Harmonic] basis. "). Purcell et al teaches "a stream processor configured to split a stream of data

associated with the lighting characteristics into multiple simultaneous operations" (*3ʳᵈ paragraph*

of section 2.3: "First, since each stream element 's computation is independent from any other,

designers can add additional pipelines that process elements of the stream in parallel. ").

42.   At the time of the invention it would have been obvious to a person of ordinary skill in

the art to define the lighting characteristics of Drebin et al through a basis function as taught by

Sloan et al. The motivation for doing so would have been provide a framework to represent

complex light transport efficiently as stated by Sloan et al in the 3ʳᵈ paragraph of section 1.

Furthermore, at the time of the invention it would have been obvious to a person of ordinary skill

in the art to include the stream processor taught by Purcell et al on the GPU in the graphics-

processing unit disclosed by Drebin et al to carry out the computations needed by the method

taught by Sloan et al. The motivation to combine the Drebin et al and Sloan et al combination

with Purcell et al would have been to efficiently implement ray tracing as stated by Purcell et al

in the 3ʳᵈ paragraph of section 2.3.

43.   Claim 40 is met by the combination of Drebin et al, Sloan et al and Purcell et al, wherein

Drebin et al discloses "a display screen in communication with the GPU, the display screen

configured to present image data representing the object" (*lines 3-5 of column 6: "The graphics*

and audio processor 114 processes these commands to generate interesting visual images on

display 59... ").

44.   Claim 41 is met by the combination of Drebin et al, Sloan et al and Purcell et al, wherein

Drebin et al discloses a computing device that is a "video game console" (*lines 5-8 of column 5:*

"To play a video game or other application using system 50, the user first connects a main unit

54 to his or her color television set 56 or other display device by connecting a cable 58 between

the two.").

45.   Claim 45 is met by the combination of Drebin et al, Sloan et al and Purcell et al, wherein

Drebin et al discloses "the GPU is further configured to render the object through a process

involving linear interpolation, such that the lighting characteristics are applied to the rendered

object" (*lines 11-16 of column 9: "In the example embodiment, transform unit 300 supports*

lighting in hardware as a per-vertex calculation. This means that a color (RGB) value can be

computed for every lit vertex, and that these colors can be linearly interpolated over the surface

of each lit triangle.").

46.   Claim 42 is met by the combination of Drebin et al, Sloan et al and Purcell et al, wherein

Purcell et al teaches a "stream processor is a programmable hardware unit capable of executing

code that is replicated multiple times" (*paragraph 2 of section 2.3: "The system executes a*

program or kernel on each element of the input stream...In this sense, a programmable graphics

processor executes a vertex program on a stream of vertices..."; 3rd paragraph of section 2.3:

"First, since each stream element 's computation is independent from any other, designers can

add additional pipelines that process elements of the stream in parallel.").

47.   Claim 43 is met by the combination of Drebin et al, Purcell et al and Sloan et al, wherein

Purcell et al teaches "code that is replicated multiple times is configured to process one of a ray

tracing algorithm" (*Figure 2: A streaming ray tracer; 5th paragraph of section 6: "We implement*

ray tracing kernels as fragment programs. ") and "multiply and add operations in the stream

processor" (*Figure 5: code for ray tracing triangles.*). Purcell et al does not use the explicit

language "multiply and add operations", but one of ordinary skill in the art would recognize that

this feature is inherent from lines 12, 14, and 15 in the code presented in Figure 5, where the dot

product of two vectors is computed.

48.   Claim 44 is met by the combination of Drebin et al, Purcell et al and Sloan et al, wherein

Purcell et al teaches "the ray tracing algorithm determines a direct illumination lighting

characteristic in real time and the multiply an add operation determine a secondary lighting

characteristic in real time" (*4th paragraph of section 3: "Additionally, the shading kernel may*

generate shadow or secondary rays; in this case, these new rays are passed back to the traversal

stage. "; 3rd paragraph of section 3.1.4: "The shading kernel optional generates shadow,

reflection, refraction, or randomly generated rays. "). With regard to the direct illumination

limitation, Purcell et al does not use this explicit language; however, one of ordinary skill in the

art would recognize that this feature is inherent from the statement in paragraph 3 of section

4.3: *"Reflect" applies a two bounce reflection and a single light source shading model to each*

primitive in the scene. The direct illumination would be computed as a single light source. With

regard to the multiply and add operations for secondary lighting for secondary illumination, the

triangle intersection stage (as shown in Figure 2 on page 705 of Purcell et al) occurs after the

traversal stage. Figure 5 (Code for ray-triangle intersection) shows the dot product operation for

two vectors on lines 12, 14, and 15. Furthermore, Purcell et al refers to the method as "an

alternative approach to real time ray tracing" in the first sentence of the 2nd paragraph of section

1.

49.   Claim 46 is met by the combination of Drebin et al, Purcell et al and Sloan et al, wherein

Sloan et al teaches the basis function is a spherical basis function (*1st paragraph of section 4:*

"...we first parameterize incident lighting at points p ∈ O, denoted $L_p(s)$, using the [spherical

harmonic] basis.").

50.   At the time the invention was made, it would have been an obvious matter of design

choice to a person of ordinary skill in the art to use "one of a wavelet and a spherical basis

function" because Applicant has not disclosed that a wavelet basis provides an advantage. One

of ordinary skill in the art, furthermore, would have expected a basis function, and applicant's

invention, to perform equally well as either a spherical harmonic basis taught by Sloan et al or

the wavelet basis because both are suitable basis functions, as described in the specification of

the instant application (*paragraph 48: "Additionally, the transfer and illumination functions may*

be expressed as the sum of any suitable basis functions. Exemplary basis functions include

spherical harmonic basis functions, wavelet "), and in Sloan et al (*paragraph 4 of section*

9: "Because of its rotational invariance (equation (4)), we consider the SH basis especially useful

for our low-frequency lighting application compared to alternatives like spherical wavelets

[37]. ").

51.   Therefore, it would have been prima facie obvious to modify the Drebin et al, Purcell et

al, and Sloan et al combination to obtain the invention as specified in claim 46 because such a

modification would have been considered a mere design consideration which fails to patentably

distinguish over the prior art of the Drebin et al, Purcell et al, and Sloan et al combination.

Conclusion

52.   The prior art made of record and not relied upon is considered pertinent to applicant's

disclosure. Nathan A. Carr, Jesse D. Hall and John C. Hart, "The Ray Engine," March 2002,

Tech. Rep. UIUCDCS-R-2002-2269, Department of Computer Science, University of Illinois,

teach a ray-triangle intersection computation using a pixel shader. John D. Owens , William J.

Dally , Ujval J. Kapasi , Scott Rixner , Peter Mattson , Ben Mowery, "Polygon rendering on a

stream architecture," August 2000, Proceedings of the ACM SIGGRAPH/EUROGRAPHICS

workshop on Graphics hardware, p.23-32, teaches polygon rendering on a stream architecture.

Stephen H. Westin , James R. Arvo , Kenneth E. Torrance, "Predicting reflectance functions

from complex surfaces," July 1992, Proceedings of the 19th annual conference on Computer

graphics and interactive techniques, p.255-264 teaches using a spherical harmonic basis for

lighting calculations.

Any inquiry concerning this communication or earlier communications from the

examiner should be directed to Jason M. Repko whose telephone number is 571-272-8624. The

examiner can normally be reached on 8:30-5:00.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's

supervisor, Ulka Chauhan can be reached on 571-272-7782. The fax phone number for the

organization where this application or proceeding is assigned is 571-273-8300.

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